Minimally Invasive Nephron Sparing Management for Renal Tumors in Solitary Kidneys

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Abbreviations and Acronyms

ASA = American Society of Anesthesiologists

CT = computerized tomography

GFR = glomerular filtration rate

LPN = laparoscopic partial nephrectomy

MINSS = minimally invasive NSS

MRI = magnetic resonance imaging

NSS = nephron sparing surgery

OPN = open partial nephrectomy

RCC = renal cell carcinoma

RFA = radio frequency ablation

Submitted for publication March 18, 2009.

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† Financial interest and/or other relationship with Intuitive Surgical.

Purpose: We present a large series of minimally invasive nephron sparing surgery outcomes in solitary kidneys with a focus on treatment selection criteria, and oncological and functional outcomes.

Materials and Methods: Of 1,019 patients who underwent minimally invasive nephron sparing surgery since September 1997 at our institution 36, 36 and 29 underwent laparoscopic partial nephrectomy, cryoablation and radio frequency ablation, respectively, for tumors in a solitary kidney. Data, including patient and tumor characteristics, surgery details, complications, and postoperative renal function and intermediate term oncological outcomes in each patient, were obtained by telephone contact or from charts. The 3 groups were compared for perioperative, functional and oncological outcomes.

Results: On multivariate analysis tumor size, aspect and remnant kidney status were independent predictors of treatment selection. Cancer specific and overall survival at 2 years was 100% and 91.2% for laparoscopic partial nephrectomy, 88.5% and 88.5% for cryoablation, and 83.9% and 83.9% for radio frequency ablation, respectively. Disease-free survival was significantly better for laparoscopic partial nephrectomy than for cryoablation and radio frequency ablation (100% vs 69.6% and 33.2%, respectively, $p < 0.0001$). The mean estimated glomerular filtration rate change for laparoscopic partial nephrectomy, cryoablation and radio frequency ablation of 17, 3 and 7 ml per minute per 1.73 m^2 reflected a 26%, 6% and 13% decrease from baseline, respectively, which was statistically significant ($p = 0.0016$).

Conclusions: Laparoscopic partial nephrectomy and probe ablative procedures can be safely and efficiently done for renal tumor in patients with a solitary kidney. Intermediate term oncological outcomes are superior for laparoscopic partial nephrectomy despite somewhat poorer renal function outcomes than those of cryoablation and radio frequency ablation.

Key Words: kidney; surgical procedures, minimally invasive; kidney neoplasms; abnormalities; catheter ablation

ROUTINE use of imaging modalities has led to a 2.3% to 4.3% increase in RCC detection annually with incidental detection of small renal tumors increasing by 60%.[1] While OPN is considered the reference standard for NSS for small renal masses, several other MINSS options are now increasingly considered, including surgical excision (LPN) and probe ablative procedures such as cryotherapy and RFA. Probe ablative procedures allow in situ neoplasm destruction without histological confirmation of

0022-5347/09/1825-2150/0
THE JOURNAL OF UROLOGY®
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Vol. 182, 2150-2157, November 2009
Printed in U.S.A.
DOI:10.1016/j.juro.2009.07.066

complete cancer kill, whereas LPN permits complete tumor extirpation. Conversely probe ablative procedures allow MINSS without concern for renal dysfunction due to warm ischemia and are technically less challenging.

A renal mass in an anatomically or functionally solitary kidney is an imperative indication for NSS to maximize renal function preservation.[2] However, no established treatment guidelines exist to choose the best available MINSS alternative specifically in the presence of a solitary kidney. We present what is to our knowledge the largest series of MINSS comparative outcomes in solitary kidneys with special emphasis on modality selection, and intermediate term oncological and functional outcomes.

MATERIALS AND METHODS

At our institution 1,019 patients were treated with MINSS between September 1997 and October 2006, including LPN in 671, cryotherapy in 216 and RFA in 132. From our prospective database we identified 101 patients (9.9%) who underwent MINSS in a solitary kidney. LPN was initially reserved for small peripheral exophytic tumors but more complex tumors were treated with increasing experience. Ablative procedures were done for localized, less than 4 cm, enhancing solid renal masses in select patients with significant comorbidities, particularly percutaneous RFA in patients at greater risk for surgery under general anesthesia. The ideal surgical treatment in an individual was chosen at surgeon discretion.

Our LPN and cryoablation techniques were previously described in detail.[3,4] RFA is routinely done using sedoanalgesia on an outpatient basis. Fine needle biopsy and RFA probe introduction are performed under CT guidance. Ablation is done at a 200 W power setting, generating a core temperature of 105C, which is maintained for 10 minutes per treatment cycle. The number of cycles is determined by tumor size.

Our followup protocol for ablative procedures includes MRI on postoperative day 1, and at 3, 6, 12, 24, 36, 48 and 60 months. Kidney biopsy at the treatment site is often done 6 months after treatment and tissue is analyzed using hematoxylin and eosin staining. No viability testing was done. The presence or absence of enhancement, enhancement pattern and change in defect size are noted. Postoperative followup for LPN consists of serum creatinine measurement at 1 month and abdominal CT or MRI at 6 months and yearly thereafter in patients with pathologically confirmed renal cancer. Followup was done prospectively and kept current by ongoing contact with the patient, family and/or referring physician. Ablative procedure failure was defined as an enlarging or persistently enhancing treatment site on followup imaging or positive posttreatment biopsy. Tumor recurrence in the operated kidney was considered failed LPN.

Data on patients with a solitary kidney was reviewed. Estimated GFR was calculated using the abbreviated Modification of Diet in Renal Disease Study equation.[5] A 20% decrease in GFR was considered significant on multivariate analysis.

Statistical analysis was performed using JMP®, version 6. Nominal data were analyzed using the chi-square test. Continuous data were analyzed using ANOVA and means were compared using Student's t test. Univariate analysis was done using contingency table analysis and logistic fit model for nominal and continuous data, respectively. Multivariate regression analysis using the ordinal logistic fit model included variables with $p < 0.20$ on univariate analysis.

RESULTS

There were 36, 36 and 29 patients in the LPN, cryoablation and RFA groups, respectively. Table 1 lists baseline demographics in the 3 groups. The incidence of solitary kidney, tumor aspect, tumor size and remnant solitary kidney status was significantly different among the treatment groups on univariate analysis (table 1). On multivariate analysis tumor aspect ($p = 0.0005$) and size ($p = 0.0066$), and remnant kidney status ($p = 0.0005$) were independent factors predicting the selection of MINSS in the setting of a solitary kidney (table 2). LPN was performed for larger tumors and all RFA was done for posterior or lateral position tumors. In contrast, 94.4% of cryoablation procedures were done laparoscopically, including 50% transperitoneally.

Probe ablative treatment duration was considerably shorter for cryoablation than for RFA (17.5 vs 33.5 minutes, $p = 0.0132$, table 3). The number of patients requiring hemodialysis was higher after LPN, which was marginally significant ($p = 0.0613$). Length of stay was highest for LPN. Nine patients with RFA underwent additional procedures, including RFA in 7 and cryoablation in 2, but 3 with cryoablation underwent additional procedures, including cryoablation, RFA and OPN in 1 each.

There were no perioperative deaths. In the LPN vs probe ablation groups there were more intraoperative complications (ureteral injury in 1 case, hemorrhage in 2 and open conversion in 2) and postoperative complications (urine leak, postoperative hemorrhage, acute renal failure and atrial fibrillation in 3 each, pneumonia in 2, and pulmonary embolus, deep vein thrombosis, sepsis, peritonitis, congestive heart failure, wound infection and epididymitis in 1 each). In the cryoablation group 1 intraoperative complication (pleural injury) developed and 5 postoperative complications, including anuria (2 cases), and urine leak, hemothorax and atelectasis (1 each). In the RFA group there were no intraoperative complications but 2 postoperative complications, including hemorrhage and blood transfusion in 1 case each. Two patients in the LPN group underwent nephrectomy and required permanent dialysis, including 1 with hemorrhage and 1 with positive margins.

Table 1. *Demographic data*

	LPN		Cryoablation		RFA		p Value
No. solitary kidneys/total No. (%)	36/671	(5.4)	36/216	(16.7)	29/132	(30.3)	<0.0001 (chi-square test)
Mean ± SD age (range)	60.3 ± 15.5	(20–87)	64.1 ± 11.1	(35–83)	60.7 ± 14.3	(30–87)	0.4532 (chi-square test)
Mean ± SD kg/m^2 body mass index (range)	30.5 ± 7.1	(17.9–53.0)	31.3 ± 5.7	(24.3–48.0)	30.0 ± 7.5	(22.5–51.6)	0.7782 (chi-square test)
No. male (%)	21	(58)	23	(64)	18	(62)	0.8859 (1-way ANOVA)
No. ASA score 3 or greater (%)	24	(66.7)	28	(77.7)	20	(69)	0.5508 (1-way ANOVA)
No. contralat kidney status (%):							0.8035 (1-way ANOVA)
Prior nephrectomy for Ca	24	(66.7)	27	(75)	23	(79.3)	
Prior nephrectomy for other reasons	4	(11.1)	3	(8.3)	2	(6.9)	
Less than 10% function	5	(13.9)	4	(11.1)	1	(3.5)	
Congenitally absent	3	(8.3)	2	(5.6)	3	(10.3)	
Mean ± SD cm tumor size (range)	3.7 ± 1.9	(1.4–10.7)	2.5 ± 1.1	(1.1–5.0)	2.6 ± 1.0	(0.9–4.2)	0.0014 (chi-square test)
No. multiple tumors (range)	1	(1–2)	7	(1–3)	6	(1–3)	0.0639 (1-way ANOVA)
No. remnant solitary kidney (%)	0		6	(16.7)	10	(34.5)	0.0008 (1-way ANOVA)
No. tumor location (%):							0.4399 (1-way ANOVA)
Upper	8	(22.2)	13	(36.1)	8	(27.6)	
Middle	16	(44.4)	10	(27.8)	8	(27.6)	
Lower	12	(33.3)	13	(36.1)	13	(44.8)	
No. tumor depth (%):							0.0935 (1-way ANOVA)
Central	14	(38.9)	6	(16.7)	10	(34.5)	
Peripheral	22	(61.1)	30	(83.3)	19	(65.5)	
No. tumor aspect (%):							<0.0001 (1-way ANOVA)
Anterior	12	(33.3)	18	(50)	0		
Posterior	12	(33.3)	12	(33.3)	26	(89.7)	
Lat	12	(33.3)	6	(16.7)	3	(10.3)	

Final histopathology results revealed RCC in 23 patients (63.8%) in the LPN group (table 4). RCC was diagnosed by intraoperative biopsy in 22 (73.3%) and 24 patients (82.8%) in the cryoablation and RFA groups, respectively (table 4). Preoperative biopsy results were not available in 6 patients with cryoablation. Six-month postoperative biopsy was not done in 10 patients with cryoablation and in 13 with RFA. Six month posttreatment biopsy revealed persistent RCC architecture in 2 patients (10%) with cryoablation and in 6 (62.5%) with RFA.

Table 5 shows overall renal function data. The increase in serum creatinine at 6-month followup was more pronounced after LPN, followed by that in the cryoablation group. As determined by estimated GFR, renal function decreased in 32 (89%), 26 (72.2%) and 16 patients (55.2%) with LPN, cryoablation and RFA, respectively. Further analysis to predict postoperative renal dysfunction revealed that 2 variables, that is preoperative estimated GFR (OR 1.05, 95% CI 1.02–1.09, p = 0.0002) and treatment type (OR 4.14, 95% CI 1.87–10.16, p = 0.0005), were significant predictors of decreased renal function at 6 months with LPN associated with the greatest decrease (table 6).

There were no cancer specific deaths after LPN at a median followup of 42.5 months. Four patients treated with cryoablation died at a median followup of 24 months, including 3 (8.3%) of metastatic RCC. In the RFA group 4 patients (13.8%) died, including 3 (10.3%) of metastatic disease. Table 7 lists 2-year cancer specific, overall and disease-free survival. The figure shows Kaplan-Meier curves for 2-year overall, cancer specific and disease-free survival in the 3 groups.

Six patients (16.7%) with cryoablation and 11 (37.9%) with RFA had persistent enhancement or growth of the treated lesion on postoperative imaging. Two patients with cryotherapy and 4 with RFA with radiographic failure had RCC on followup biopsy. One of 6 patients with radiographic failure in the cryotherapy group underwent repeat cryotherapy, 1 underwent RFA, 1 underwent OPN and 3 are being followed closely with radiography. Three patients had metastatic disease 3, 6 and 12 months after treatment, respectively. Of 11 patients with

Table 2. *Univariate and ordinal logistic fit model multivariate analysis to predict treatment selection in solitary kidneys*

Variable	Univariate p Value	Multivariate p Value
Age	0.7896	
Body mass index	0.7970	
Gender	0.8859	
ASA score	0.4607	
Preop serum creatinine	0.1580*	0.6070
Preop estimated GFR	0.1886*	0.8136
Tumor location (upper/middle/lower)	0.4829	
Tumor aspect (anterior/lat/posterior)	0.0002*	0.0005
Tumor depth (central/peripheral)	0.1959*	0.2995
CT tumor size	0.0009*	0.0066
Remnant kidney (yes/no)	0.0010*	0.0005

* Variables at p <0.20 on univariate analysis were selected for multivariate analysis.

Table 3. *Intraoperative and postoperative data*

	LPN	Cryoablation	RFA	p Value
No. approach (%):				<0.0001 (chi-square test)
Transperitoneal	19 (52.8)	18 (50)	0	
Retroperitoneal	17 (47.2)	15 (41.7)	0	
Percutaneous	0	3 (8.3)	29 (100)	
Mean ± SD mins operative time (range)	223 ± 81 (135–480)	181 ± 69 (35–330)	Not applicable	0.0738 (1-way ANOVA)
Mean ± SD probes/cycles (range)	Not applicable	1.4 ± 0.7 (1–3)	2.7 ± 1.1 (1–5)	Not applicable
Mean ± SD mins warm ischemia/ablation time (range)	31.3 ± 11.8 (14–55)	17.5 ± 8.42 (9–45)	33.5 ± 9 (8–67)	0.0132 (1-way ANOVA)
Mean ± SD ml estimated blood loss (range)	408 ± 800 (50–4,500)	151 ± 171 (10–800)	Not applicable	0.0605 (1-way ANOVA)
No. intraop adverse events (%)	5 (13.9)	1 (2.8)	0	0.0379 (chi-square test)
Mean ± SD days hospital stay (range)	3.3 ± 2.6 (1.3–12)	1.8 ± 1.3 (0.9–6)	1 ± 0 (1–1)	<0.0001 (chi-square test)
No. postop complications:	21	5	2	<0.0001 (chi-square test)
Urological	9	3	1	
Nonurological	12	2	1	

radiographic failure in the RFA group 7 underwent repeat RFA, 2 underwent cryotherapy (including 1 with additional sunitinib), 1 underwent radiotherapy to the brain and liver ablation, and 1 elected close radiographic monitoring. Four patients had metastatic disease 6, 20, 23 and 28 months after treatment, respectively. No patients with cryoablation and 2 with RFA had positive renal carcinoma histology on 6-month post-ablation biopsy despite no enhancement or growth of the ablation lesion on radiological imaging. One of the 2 patients with positive surgical margins in the LPN group underwent completion nephrectomy and 1 elected observation.

DISCUSSION

Pertinent issues in RCC management in patients with a solitary kidney are cancer cure, renal function deterioration, complication risk, competing comorbidities and life expectancy. In this large MINSS series LPN oncological outcomes were superior. RFA had the highest radiographic failure rate in all groups, although this is a retrospective comparison with differing selection criteria. Cancer specific and all cause survival was 100% and 91.2% for LPN, 88.5% and 88.5% for cryotherapy, and 83.9% and 83.9% for RFA, respectively, which did not attain statistical significance, possibly due to differences in followup length. These data must be carefully analyzed since there were more patients with synchronous or metachronous multiple tumors in the ablative groups. Also, metastatic lesions noted shortly after probe ablation may have predated treatment as micrometastatic spread. Nevertheless, tumor size was significantly greater in the LPN group.

The initial 5-year report after LPN revealed excellent oncological and functional outcomes with 86% overall and 100% cancer specific survival at a median followup of 5.7 years in 58 patients.[6] Although followup for probe ablative therapy is shorter than for extirpative procedures, preliminary 5-year cryotherapy and 1 to 4-year RFA oncological outcomes are encouraging with 98% and 98.5% cancer specific survival, respectively.[7,8] However, most tumors treated in these series were less than 3 cm. Klingler et al recently evaluated histopathological outcomes of new generation RFA in 17 patients undergoing immediate LPN.[9] They noted vital tumor

Table 4. *Histopathological data*

	No. LPN	No. Preop Cryoablation	No. Preop RFA
No. pts	36	30	29
RCC histology (%):	23 (63.8)	22 (73.3)	24 (82.8)
Clear cell	19	Not applicable	Not applicable
Papillary	4	Not applicable	Not applicable
Benign conditions/biopsy (%):	13 (36.2)	8 (26.7)*	5 (17.2)
Oncocytoma	8	2	2
Angiomyolipoma	3	1	—
Cyst	2	—	—
Neg Ca	—	5	2
Insufficient material	—	—	1
Pos surgical margins (%)	2 (5.5)	Not applicable	Not applicable
Mean cm margin width (range)	0.45 (0.1–1.3)	Not applicable	Not applicable

* Preoperative biopsy results not available in 6 patients.

Table 5. *Renal function data*

	LPN	Cryoablation	RFA	p Value
Mean ± SD mg/dl serum creatinine (range):*				
Preop	1.2 ± 0.4 (0.7–2.1)	1.4 ± 0.5 (0.8–2.9)	1.4 ± 0.5 (0.6–3.3)	0.1390 (1-way ANOVA)
Postop	1.6 ± 0.6 (0.8–3.3)	1.6 ± 0.7 (0.5–3.8)	1.5 ± 0.8 (0.8–5.0)	0.7655 (1-way ANOVA)
Increase	0.4 ± 0.5	0.2 ± 0.3	0.1 ± 0.4	0.0283 (1-way ANOVA)
No. serum creatinine change (%):*				0.0376 (chi-square test)
Increased	32 (89)	26 (72.2)	16 (55.2)	
Unchanged	2 (5.5)	7 (19.5)	7 (24.1)	
Decreased	2 (5.5)	3 (8.3)	6 (20.7)	
Mean ± SD ml/min/1.73 m^2 GFR (range):*				
Preop	65 ± 23.5 (25–108)	52.3 ± 19.7 (23.1–116.9)	53.2 ± 16.2 (22.7–86.6)	0.2043 (1-way ANOVA)
Postop	48 ± 17 (20–84)	51 ± 27 (17–172)	52 ± 15 (14–84)	0.7047 (1-way ANOVA)
Decrease	18 ± 17	3 ± 17	7 ± 15	0.0025 (1-way ANOVA)
No. baseline chronic kidney disease (%):†	23 (63.9)	26 (55.6)	17 (58.6)	0.5054 (chi-square test)
No. GFR change (%):*				0.5805 (chi-square test)
Increased	2 (5.5)	4 (11.1)	4 (13.8)	
Unchanged	3 (8.3)	5 (13.9)	5 (17.3)	
Decreased	31 (86.2)	27 (75)	20 (68.9)	
No. hemodialysis (%):				0.0613 (chi-square test)
Temporary	3	0	0	
Permanent	2	0	0	

* Excluding 2 patients on permanent dialysis.
† GFR less than 60 ml per minute per 1.73 m^2.

using nicotinamide adenine dinucleotide diaphorase staining in 24% of ablated renal lesions, emphasizing that skipping may still be a problem. Such reports raise doubt about the oncological adequacy of RFA. That group believes that there is a clear need for a definitive evaluation of the ability of RFA to destroy small renal tumors.

In our series multivariate analysis revealed that tumor size and aspect, and remnant kidney status were the 3 independent factors affecting our treatment choice. Gervais et al reported one of the largest series of RFA in 85 patients with a mean followup of 2.3 years.[10] On multivariate analysis small tumor size and peripheral tumor location were independent predictors of success. Other potential variables that may impact treatment choice are comorbidity type and severity. The difference in ASA scores in this population was not statistically significant between groups, suggesting that the ASA classification system may not be ideally suited to assess the quality and severity of comorbid conditions for treatment decisions.

Overall multifocality is seen in 6% to 25% of RCC cases and in 0% to 5% when the primary tumor is less than 4 cm.[11] Although to our knowledge no predictable relationship between multifocality and local recurrence has been reported, we often prefer

Table 6. *Univariate and ordinal logistic fit model multivariate analysis to predict greater than 20% estimated GFR decrease in solitary kidneys after MINSS*

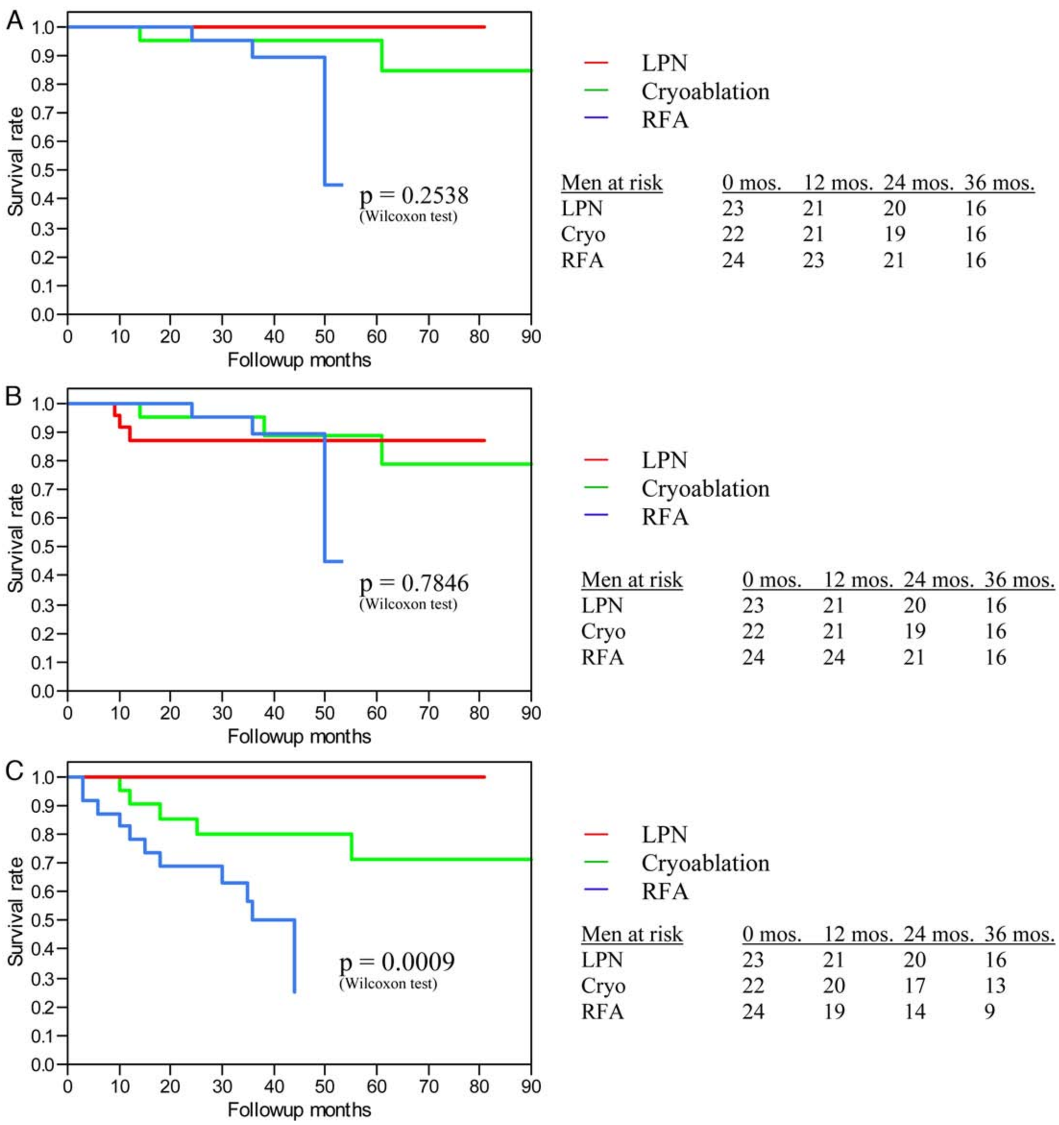
Variable	Univariate p Value	Multivariate p Value	OR (95% CI)
Age	0.6378		
Body mass index	0.2167		
Gender	0.3133		
ASA score	0.6190		
Preop serum creatinine	0.2644		
Preop estimated GFR	0.0020*	0.0002	1.0514 (1.0222–1.0905)
Location:			
Upper/middle/lower	0.9695		
Anterior/lat/posterior	0.2889		
Central/peripheral	0.0744*	0.0524	0.5345 (0.2690–1.0065)
CT tumor size	0.1148*	0.9775	0.9946 (0.6895–1.4697)
Procedure (LPN/cryoablation/RFA)	0.0002*	0.0005	4.1449 (1.8737–10.168)

* Variables at p <0.20 on univariate analysis were selected for multivariate analysis.

Table 7. *Oncological outcomes*

	LPN*	Cryoablation*	RFA†
No. pts	36	36	29
Median mos followup (range)	42.5 (7–81)	24.0 (1–84)	14.0 (1–44)
No. recurrence:			
Local	0	6	13
Distant	0	3	4
No. death:			
RCC	0	3	3
Other cause	3	1	1
% 2-Yr survival (95% CI):			
Ca specific	100	88.5 (82.2–94.8)	83.9 (73.5–94.4)
Overall	91.2 (82.4–98.6)	88.5 (82.2–94.8)	83.9 (73.5–94.4)
Disease-free	100	69.6 (61.0–78.3)	33.2 (22.3–44.0)

* Started September 1997.
† Started January 2003.



Kaplan-Meier estimates. *A*, cancer specific survival. *B*, overall survival. *C*, disease-free survival.

probe ablative procedures for multiple tumors in solitary kidneys mainly to avoid the prolonged ischemic insult that would be required for LPN. The role of preoperative renal biopsy is evolving and with improvement in the diagnostic quality of these evaluations their use in treatment decision making may be enhanced.[12]

From a functional standpoint considering estimated GFR and serum creatinine patients have a better overall renal functional outcome after probe ablative procedures than after LPN. There is a higher likelihood of requiring temporary or permanent dialysis after LPN, highlighting the fact that patients with preoperative renal insufficiency and a solitary kidney are at greater risk for dialysis. Recently Nguyen and Gill modified their LPN technique to decrease average warm ischemia time to less than 15 minutes, which may improve functional outcomes for LPN in solitary kidneys in the future.[13] Notably larger tumor size and, thus, greater resection (treatment) area in the LPN group could at least partly account for the larger GFR deficit in this group.

Gill et al reported outcomes in 22 patients who underwent LPN in a solitary kidney.[14] Mean tumor size was 3.6 cm and mean warm ischemia time was 29 minutes (range 14 to 55). Median preoperative and postoperative serum creatinine (1.2 and 1.5 mg/dl), and estimated GFR (67.5 and 50 ml per minute per 1.73 m^2) reflected a 33% and 27% change, respectively, commensurate with the 23% of parenchyma excised. Our report includes these initial 22 patients and another 14 more recent LPNs. There is also a series on each ablative procedure in the literature showing the feasibility and safety of cryoablation and RFA in solitary kidneys. Table 8 lists MINSS outcomes in solitary kidneys in the published literature.[14–18]

Table 8. *Outcome of MINSS for renal tumor in solitary kidney in literature*

	Shingleton and Sewell[15]	Bhayani et al[17]	Gill et al[14]	Jacobsohn et al[16]	Present Series
Procedure	Cryoablation	LPN	LPN	RFA	LPN, cryoablation,* RFA†
No. pts	14	4	22	16	36, 36, 29
Mean tumor size (cm)	3.1	2.2	3.6	3.4	3.7, 2.5, 2.6
Renal function	No significant change	Serum creatinine returned to baseline	GFR decreased 27%	Renal function maintained in all but 1 pt	GFR decreased 26%, 6%, 13%
% Survival:				Not available	
Ca specific	100	100	100		100, 88.5, 83.9
Overall	100	100	91		91, 88.5, 83.9
Mean followup (mos)	16.3	17	30	15.3	42.5, 24, 14
Complications (No. pts)	Major (0) + minor hematuria (2)	Major (0) + minor transfusion (1)	Major ureteral injury (1), hemorrhage (1), pulmonary embolism (1) + minor atrial fibrillation (3), pneumonia (1), deep vein thrombosis (1), epididymitis (1)	Major clot obstruction (3), hemorrhage (1), renal failure (1), ureteral stricture (1)	Intraop (5, 1, 0) + postop (21, 6, 2)

* Local recurrence in 6 patients.
† Local recurrence in 13 patients.

This retrospective study should not be viewed as a direct comparison among the 3 procedures since considerable selection bias exists among the groups. Our data suggest that cryoablation results in more consistent and reliable renal tumor tissue destruction than RFA. In contrast, 16.7% of patients with cryoablation and 37.9% with RFA had persistent enhancement or growth in the size of the treated lesion. Also, 2 patients with RFA had positive biopsy despite negative radiographic imaging.

Probe ablative techniques have lower morbidity and complication rates than LPN. Overall complication rates were low for each type of probe ablation in the current series despite high preoperative comorbidity in the 2 groups. Although it was not the case in our study, a concern about probe ablative treatments, particularly for central lesions, is the potential for injury to the collecting system and other vital renal structures. However, in our series 16.7% of tumors treated with cryoablation and 34.5% treated with RFA were adjacent to the sinus, calices or hilum and only 1 collecting system complication was noted. Most study patients were treated before there were warnings on chronic renal insufficiency and MRI related nephrogenic systemic fibrosis. An individualized approach to followup imaging with contrast CT or MRI depending on the degree of renal insufficiency must be agreed on by patient and clinician.

To our knowledge we present the largest clinical experience to date with MINSS for renal tumors in solitary kidneys. Limitations of this study are inherent to its retrospective nature, and differing followups and strategies. Complete pathological analysis is not available since probe ablative procedures rely on radiographic imaging and postoperative needle biopsy instead of on whole specimen histopathological analysis, as for LPN.

CONCLUSIONS

A solitary kidney is an imperative indication for NSS for renal tumor. In our nonrandomized, retrospective review LPN was the most oncologically sound NSS among the minimally invasive treatment alternatives with seemingly poorer renal functional results and a higher complication rate. The disease-free survival rate for probe ablative therapy in this retrospective series was significantly lower than for LPN in solitary kidneys, in particular for RFA. Cryotherapy may provide acceptable oncological outcomes with good functional results.

ACKNOWLEDGMENTS

Dedicated to the memory of Dr. Andrew C. Novick.

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EDITORIAL COMMENT

This relatively large, retrospective MINSS series in solitary kidneys helps answer some questions on our approach to this often difficult problem. More importantly examining the results prompts some other issues for consideration. The individual questions will ultimately determine treatment approach and appropriate patient counseling.

Table 4 shows the significant percent (17% to 36%) of benign lesions in this series and represents an opportunity to improve selection based on preoperative imaging and potential biopsy. The lower disease specific survival but better functional results for probe ablative techniques suggest that we must look at risk factors for failure in these cases, such as broad based central lesions.[1] These authors correctly state the goal of treating the tumor appropriately while maintaining postoperative function. Thus, the hemodialysis rate and greater decrease in GFR in the LPN group would suggest that one should also examine preoperative risk factors[2] of poorer success to consider OPN under cold ischemia.

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